Shock Recrystallisation and Decomposition of Zircon.

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Zircon ($ZrSiO_4$) forms polycrystalline aggregates at ultrahigh post-shock temperatures, and can decompose to monoclinic ZrO_2 (baddeleyite) or tetragonal ZrO_2 and SiO_2 [1-6]. It is important to understand the recrystallization mechanisms of these phenomena because they can be associated with variable resetting of the U-Pb isotope system in zircon [7]. In this study, we present the first EBSD characterization of granular and decomposed zircon in order to investigate the mechanism(s) by which these microstructures are produced. Of the 79 zircon grains identified in an impact melt rock from the ~90 km Acraman impact structure, South Australia, 25 % are single crystals with primary oscillatory growth zoning CL patterns. These grains are interpreted to be unshocked relicts from the target rock. The remaining 75 % of the grains preserve a range of granular textures. Weakly deformed grains show relict CL zones, have networks of low-angle (<10°) boundaries with misorientation axes clustered around <001> and along {110}, indicative of dislocation creep. Small (~1 µm) rounded neoformed granules have either systematic misorientation relationships with the host grains, chiefly 90° / <110>, 65° / <110>, or are randomly oriented. With more intense granule development, overall CL intensity is significantly reduced, primary zoning is lost, and/or individual granules show concentric CL zoning. Granules in these grains show greater orientation dispersion with higher proportions of systematically misoriented granules, consistent with nucleation of granules within shock-deformed zircon in the solid state. The observed orientation relationships could be explained by granule nucleation at crystal defect sites, such as low-angle boundaries, shock twin and reidite lamellae interfaces, in which case impinging nuclei inherit crystallographic orientation locally, so that nucleation from a shock twin results in 65° / <110>, and nucleation and reversion from reidite yields 90° / <110>. The crystallographic relationships between the granules implies that either (1) dislocation creep, twinning and reidite formation preceded granule development, even though no reidite or twin lamellae remain. In which case, the host zircon must have at least retained short-range order prior to granule development, enabling orientation inheritance; or (2) granules physically rotated into orientations with low interfacial energies. Conversely, dispersed granules with interstitial non-zircon groundmass are randomly oriented, indicating neither orientation inheritance nor rotation. Baddeleyite is present in 16 % of the grains as <1 µm domains enclosed within larger, more dispersed zircon granules. Impinging baddeleyite and zircon grains show a variety of crystallographic relationships. The range of shared crystallographic directions (within 5 degrees) possibly results from multiple symmetrically equivalent martensitic transformations from zircon to baddeleyite, and maybe tetragonal ZrO_2, before and during an equally complex cooling history.

References: [1] Bohor B.F. et al. 1993. *Earth Planet. Sci. Letts.* 119:419-424. [2] Kamo S.L. et al. 1996. *Earth Planet. Sci. Letts.* 144:369-387. [3] Glass B.P. and Liu S. 2001. *Geology* 29:371-373. [4] Wittmann A. et al. 2006. *Met. Planet. Sci.* 41:433-454. [5] El Goresy A. 1965. *J. Geophys. Res.* 70:3453-3456. [6] Kusaba K. et al. 1985. *Earth Planet. Sci. Letts.* 72:433-439. [7] Krogh T.E. et al. 1993. *Nature* 366:731-734.